Big data can help doctors predict which COVID patients will become seriously ill

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The pandemic continues to pose huge challenges to health services worldwide. Hospitals are in crisis as the pace of new COVID-19 cases outstrips their capacity. What makes things particularly difficult is that

the coronavirus doesn't affect everyone in the same way.

Being able to better predict which patients will get seriously ill would allow hospitals to use their stretched resources more effectively. Armed with such information, hospitals could stop admitting patients who are at low risk of deteriorating and avoid administering unnecessary treatments. And for patients at high risk, this information could guide doctors on how and when to treat them.

Researchers have been racing to develop "prediction models" for this very purpose since the start of the pandemic. Prediction models are created by learning from previous patients, and they need to be fed a lot of data. Early models were found to be inadequate for clinical use, mainly because they didn't include enough data to capture the variety of scenarios that occur among different patients and across different settings.

But there is a study—called ISARIC4C – that is collecting data on patients with COVID-19 from over 250 hospitals across the UK. We believed that this could be a powerful platform for addressing this problem. So, working with colleagues from across the UK, we set about creating a prediction model using ISARIC4C's data that would be good enough to be used clinically.

Using big data to improve care

We used ISARIC4C data from approximately 75,000 patients across England, Scotland and Wales to develop our prediction tool, which we called the 4C deterioration model. It's designed to predict the risk of an adult hospitalised with COVID-19 requiring breathing support, needing intensive care or dying during their hospital stay.

The model requires only routinely collected information. It needs to

know the person's age and sex, whether they developed their infection inside or outside hospital, their bedside assessments—such as oxygen level, rate of breathing and consciousness level—and a selection of common blood tests and chest X-ray findings. These 11 data inputs (or "predictors") were included based on previous reports of them being associated with severe COVID-19 together with evidence from the ISARIC4C study associating them with deterioration.

A patient's predictors are combined together in the 4C deterioration model using an equation, which then provides the percentage likelihood of that patient's condition worsening. The predictors aren't equal, but are weighted according to their association with deterioration. For example, the strongest predictor in the model is blood oxygen level (measured using a finger probe). This is because a reduction in oxygen levels is the main mechanism through which COVID-19 causes critical illness.

We tested the accuracy of the predictions in hospitalised COVID-19 patients across nine NHS regions in England, Scotland and Wales. Our analyses showed that the model's predictions closely matched the observed outcomes of patients. For example, using a measure called a "calibration slope" to see how well predictions matched up with real outcomes, the model scored 0.96 compared with a perfect score of 1. These results offered encouraging evidence that the model could usefully guide medical decision making in all regions.

How doctors can use the tool

We made the 4C deterioration model available to doctors as an online risk calculator in January 2020. It's available alongside our 4C mortality score, a model we made previously that predicts risk of death in COVID-19 patients, and which has been recommended by NHS England to help guide antiviral treatment.

Since age is a very strong predictor of whether a COVID-19 patient will die, we recommend using both models in parallel to ensure that risk isn't underestimated among younger patients. Young people with COVID-19 can be at low risk of death but high risk of deterioration—a fact not picked up by the 4C mortality score on its own.

These prediction tools are intended to allow inherently subjective medical decision making—which may vary considerably between clinicians—to be more objective and evidence-based, particularly during challenging circumstances when resources are stretched. Predictions may be used to support discussions of prognosis with patients and families, estimate demand for resources, and inform decisions regarding keeping patients in hospital or admitting them to critical care.

Future clinical trials could also evaluate whether the tools might be useful for directing treatments with specific drugs (such as antivirals and immune modulators) towards patients who are most likely to benefit. The tools could even be used to analyse data from clinical trials that have already been run, to see if they can distinguish between patients who did and did not respond to treatment.

Importantly, the ISARIC4C study is ongoing. This means that we can continue to evaluate how the prediction tools are performing in recent groups of patients—and this will allow us to optimise them if required in the future. In addition, making the models freely available will allow researchers and policymakers worldwide to test how well our models work in their own populations.

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